Hermiticity Correlation Study

Aerospace/NASA Collaboration
San Antonio, TX
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AGENDA

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II. Instrument Correlation Study

A. Test Plan

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Purpose

What was the purpose of this study?

Conducted a round robin study of "so-called" hermetic parts with leak rate deficiencies to evaluate hermetic test equipment capability to identify fine and gross leaking parts using the various conditions specified in the MIL-STD test methods.

CHLD
(Pernicka 700H System)

Kr-85
(IsoVac Mark V Bomb Station)

OLT System
(NorCom 2020 Optical Leak Test System)

Purpose

Why is this study important?

Mission Assurance

Mitigate risks to mission critical applications

Our Concerns:

- *Correlation/suitability testing of OLT with other hermetic test equipment has not been performed, documented, and presented prior to incorporation into the MIL-STD test methods for DLA approved lab suitability*
  - *Limitations of the test equipment have not been documented and made readily available to potential users*
  - *A recent DLA site visit of NorCom, Inc. identified deficiencies in the test method and calculations; therefore any existing DLA approved lab suitability is now of concern*
- *Class K Hybrid suppliers will have to comply with the tightened leak rate limits of MIL-STD-883J TM1014.14 by June 2015*
  - *Some programs are currently requiring the tightened limits for BOTH hybrids and monolithics*
  - *MIL-STD-750 already requires the tighter leak rate requirements*

Test Plan

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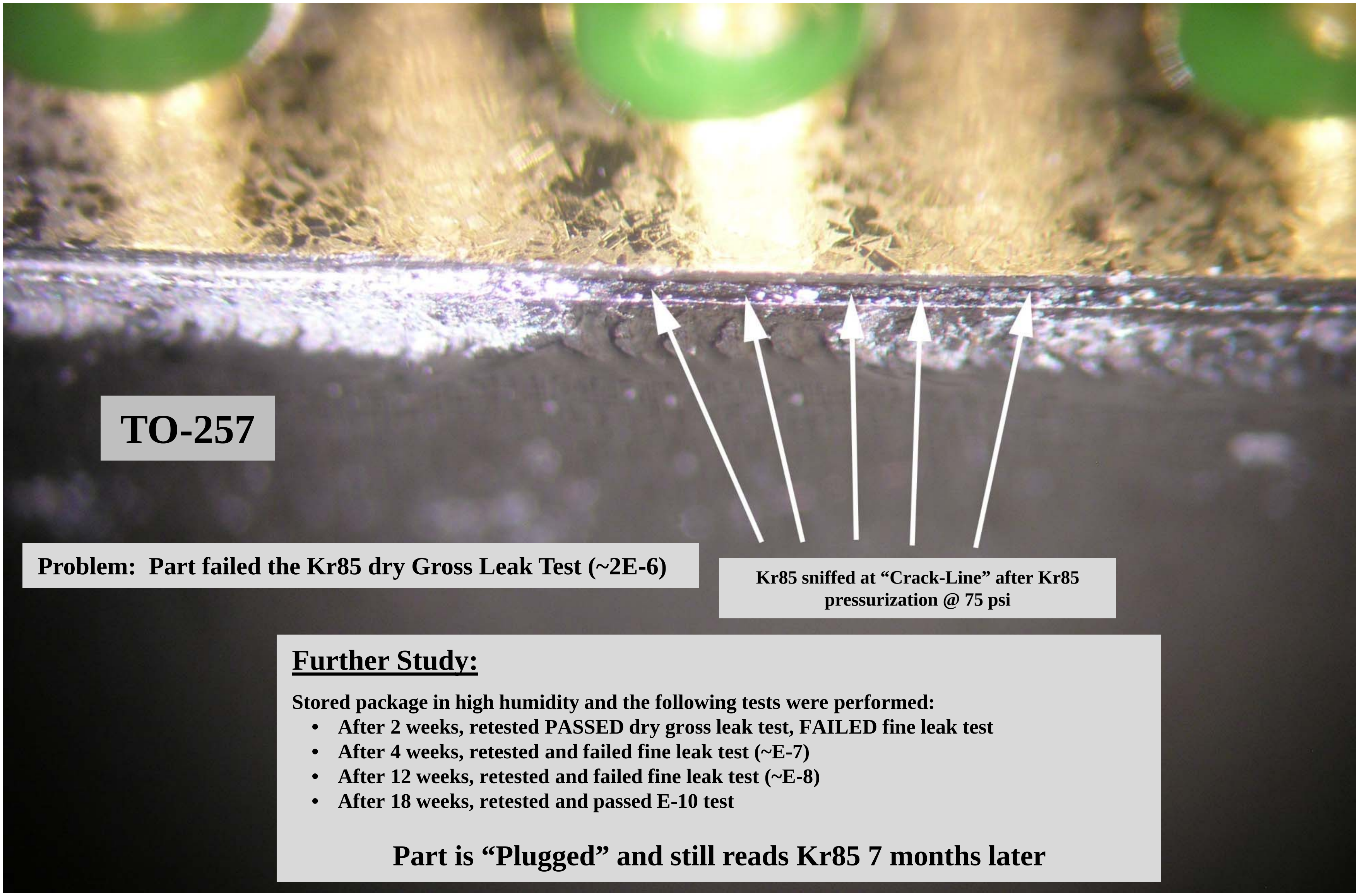
Step 1 **Secure Non-Hermetic Parts**	• Secured TO-257 style packages (QML hybrids, monolithic microcircuits, discrete semiconductors) • Four part **AIR** Leak Rate ranges: Gross Leak (≥5E-6) & Fine Leak (E-7, E-8, E-9) • LDCs: 1146, 1206, 1207, 1209, 1213, 1304 (IGA verified by Mfg.) • Parts were not exposed to fluorocarbons
Step 2 **Part Qualification**	• Kr85 test labs correlated part leak rate values (Labs A, B, and/or C) • Based on Kr85 values initial plugged parts were removed from sample pool and replaced with parts having equivalent leak rates • 2 sample sets were chosen from the qualified parts for CHLD & OLT correlation testing
Step 3 **Correlation Testing**	• **Sample Set 1**: 5 parts from E-7, E-8, E-9, and gross leak rate ranges were tested at 2 CHLD labs, Labs D & E (n=20) • **Sample Set 2**: 5 parts from E-7, E-8, and gross leak rate ranges were OLT tested at Lab F (n=15) [E-9 parts were not tested]
Step 4: **Verification Testing**	• Both sample sets were returned and Kr85 tested to compare with initial qualification data and identify any latent plugged parts which could skew correlation • IGA (100%) and vacuum decay (n=8) were used to verify samples were leakers and were not exposed to fluorocarbons.

Plugging Mechanism



Problem: Part failed the Kr85 dry Gross Leak Test (~2E-6)

Further Study:

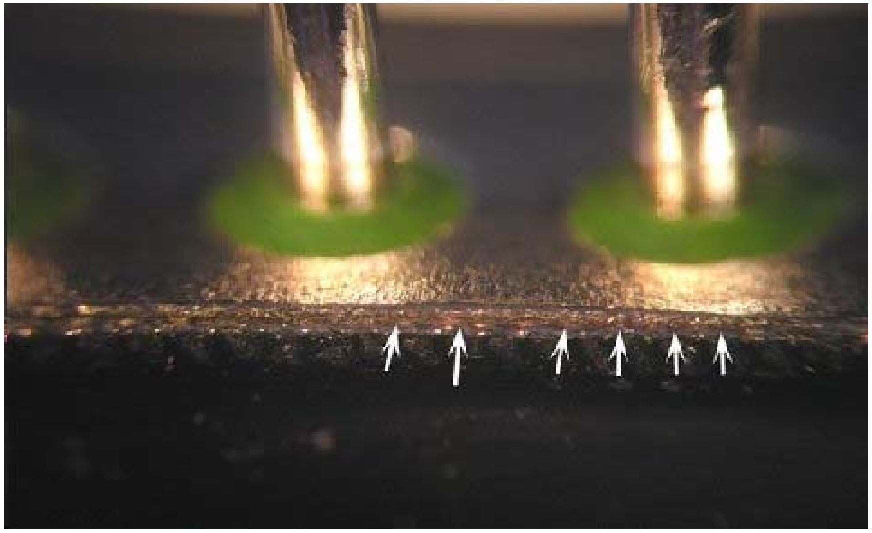
Stored package in high humidity and the following tests were performed:

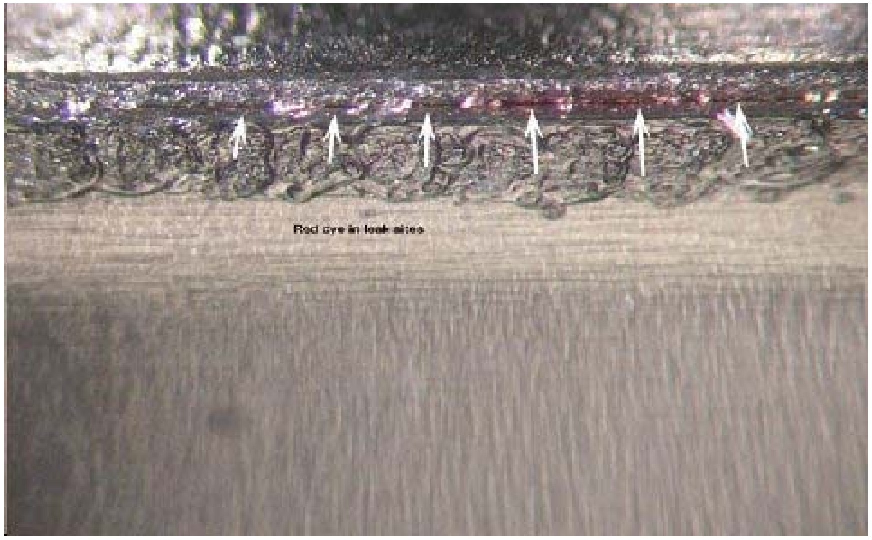
- **After 2 weeks, retested PASSED dry gross leak test, FAILED fine leak test**
- **After 4 weeks, retested and failed fine leak test (~E-7)**
- **After 12 weeks, retested and failed fine leak test (~E-8)**
- **After 18 weeks, retested and passed E-10 test**

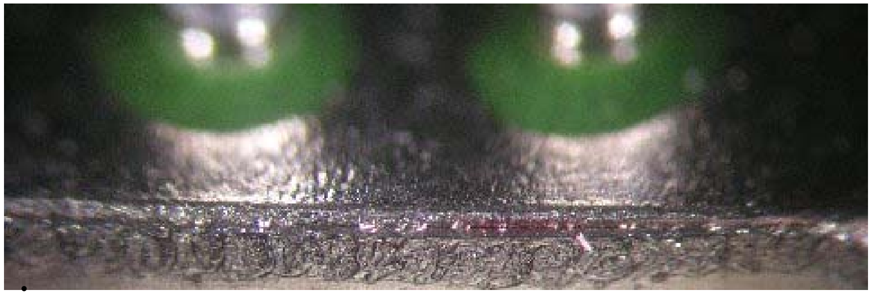
Part is “Plugged” and still reads Kr85 7 months later

Plugging Mechanism

The images below show leaks in the steel weld material of Kovar TO-257 parts. When these parts are exposed to ambient conditions, the metal compounds used in the part construction and weld material oxidize forming rust which can potentially plug existing leak paths. Gross leakers are shown below. Note that fine leaks may plug quicker. Further university research is being conducted on this mechanism.







Test Specifics

Kr85

- Labs (A,B, & C) tested in accordance with MIL-STD-883 TM1014.14
- Gross leak was performed using Test Condition B2
- Fine leak was performed using Test Condition B1
- Kr85 test conditions and system setup are summarized in a backup slide

CHLD

- Labs D & E tested in accordance with MIL-STD-883 TM1014.14 Test Condition CH2 (*1)
- Both used identical bombing conditions, inserts, & equipment setup
- CHLD test conditions and system setup are summarized in a backup slide
- **1: For fine leakers, dwell time was extended to mitigate helium desorption issues*

OLT

- Lab F tested in accordance with MIL-STD-883 TM1014.14 Test Condition L_2 (*1)
- OLT test and bombing conditions were determined by Lab F
- OLT test conditions and system setup are summarized in backup slides
- **1: Lab F only had confidence to test down to a sensitivity of 2.3E-8 atm-cc/sec He (8.5E-9 AIR) and therefore did not test the E-9 leak range samples*

All samples used in this test were quantified twice using Kr85

- **Kr85 Qualification and Verification Test Results (Labs A, B, and/or C)**
  - Initial Kr85 qualification test data was performed and individual test lab results 100% correlated within a ½ order of magnitude for all 35 parts used in this study. Those parts were then subdivided into two sets: CHLD Sample Set 1 and OLT Sample Set 2 and distributed to the participating labs for testing.
  - Final Kr85 verification test data was performed after CHLD and OLT testing to compare with initial qualification data and identify any plugged parts which could skew correlation results.
    - 14 of the 35 parts used in this study showed evidence of latent full, partial, or intermittent plugging (40%).
    - The following number of samples were excluded from this study due to Kr85 test results which indicated plugging occurred prior to final verification testing:
      - Sample Set 1 – CHLD (n=20): 6 parts (30%)
      - Sample Set 2 – OLT (n=15): OLT parts showed no signs of plugging

Kr85 qualification data demonstrates 100% correlation between test labs A, B & C

Data & Results: CHLD (Gross)

Sample Set 1 Part Information (TO-257, Vol. = 0.23 cc)			Air Leak Rate Results (atm-cc/sec Air)									IGA Sep. 2014
			Kr85 Qualification			CHLD		Kr85 Verification				
Classification	LDC	SN	Lab A Aug. 2013	Lab B Jun. 2013	Lab C May 2013	Lab D Feb. 2014	Lab E Apr. 2014	Lab A Apr. 2014	Lab B	Lab C Jul. 2014	Vacuum Decay (Lab C) Aug. 2014	Moisture (ppm)
Gross Samples	1206	211	Gross	Gross	Gross	8.9E-07	1.3E-06	Gross	Did Not Test	Gross	--	23,777
	1207	215	Gross	Gross	Gross	1.1E-06	Gross	Gross		Gross	--	17,161
	1146	221	Gross	Gross	Gross	1.5E-06	5.2E-08	PLUGGED		PLUGGED	--	11,717
	1146	224	Gross	Gross	Gross	1.9E-06	Gross	Gross		Gross	--	18,590
	1209	229	Gross	Gross	Gross	Gross	Gross	Gross		Gross	1.7E-06	15,533

- **Plugging** (Kr85 testing performed from 5/13 – 8/14)
  - Kr85 qualification test data quantified all five parts as gross leakers
  - Kr85 verification test data identified 1 plugged part (SN 221). CHLD test data indicates plugging occurred during CHLD round robin testing.
  - Based on qualification vs verification test data, only data from 4 parts are valid
- **CHLD vs Kr85 Correlation**
  - Lab D identified 3 of the 4 gross leakers as a fine leak value (within ½ order of magnitude)
  - Lab E identified 1 of the 4 gross leakers with a fine leak value (within ½ order of magnitude)
- **MIL-STD Failure Criteria L Comparison**
  - MIL-STD-883J TM1014.14 L=1E-7: Test labs A-E would have failed all 4 parts
  - MIL-STD-750F TM1071.11 L=5E-9: Test labs A-E would have failed all 4 parts
    - *The latest revision of MIL-STD-883J TM1014.14 calls out L=5E-9 for Class K Hybrids*

CHLD Labs D & E identified the leakers as gross or intermediate fine leakers

Data & Results: CHLD-Fine (E-7)

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Sample Set 1 Part Information (TO-257, Vol. = 0.23 cc)			Air Leak Rate Results (atm-cc/sec Air)									IGA Sep. 2014
			Kr85 Qualification			CHLD		Kr85 Verification				
Classification	LDC	SN	Lab A Aug. 2013	Lab B Jun. 2013	Lab C May 2013	Lab D Feb. 2014	Lab E Apr. 2014	Lab A Apr. 2014	Lab B	Lab C Jul. 2014	Vacuum Decay Aug. 2014	Moisture (ppm)
E-7 Samples	1213	103	1.0E-07	2.4E-07	1.4E-07	8.7E-08	3.0E-07	1.0E-07	Did Not Test	PLUGGED	--	10,200
	1213	109	1.4E-07	2.8E-07	2.0E-07	1.7E-08	3.9E-07	1.6E-07		7.0E-07	--	10,400
	1213	119	1.1E-07	1.4E-07	1.0E-07	1.4E-08	2.7E-07	1.4E-07		PLUGGED	--	15,700
	1207	316	4.4E-07	8.0E-07	6.4E-07	1.0E-06	8.6E-07	5.1E-07		1.4E-07	--	38,440
	1207	351	1.7E-07	3.0E-07	2.0E-07	1.7E-07	2.8E-07	1.6E-07		4.3E-09	--	14,964

- **Plugging** *(Kr85 testing performed from 5/13 – 7/14)*
  - Kr85 qualification test data quantified all 5 parts as 10^{-7} fine leakers
  - Kr85 verification test data identified 3 fully or partially plugged parts
  - Based on Lab A qualification versus verification data, data from all 5 parts is valid
- **CHLD vs Kr85 Correlation**
  - CHLD Lab D correlated 3 of the 5 known leakers within ½ order of magnitude to Kr85 qualification data. CHLD Lab E correlated 5 of the 5 known leakers within ½ order of magnitude to Kr85 qualification data.
  - Deviations between Lab D & E CHLD data needs further investigation to determine root cause. These differences may be a function of operator experience and equipment complexity.
- **MIL-STD Failure Criteria L Comparison**
  - MIL-STD-883J TM1014.14 L=1E-7: Test labs A-E would have failed all 5 parts
  - MIL-STD-750F TM1071.11 L=5E-9: Test labs A-E would have failed all 5 parts
    - *The latest revision of MIL-STD-883J TM1014.14 calls out L=5E-9 for Class K Hybrids*

CHLD Lab D correlated 3 of 5 parts & CHLD Lab E 5 of 5 parts within ½ order of magnitude

Data & Results: CHLD-Fine (E-8)

Sample Set 1 / Part Information (TO-257, Vol. = 0.23 cc)			Air Leak Rate Results (atm-cc/sec Air)									IGA Sep. 2014
			Kr85 Qualification			CHLD		Kr85 Verification				
Classification	LDC	SN	Lab A Aug. 2013	Lab B Jun. 2013	Lab C May 2013	Lab D Feb. 2014	Lab E Apr. 2014	Lab A Apr. 2014	Lab B	Lab C Jul. 2014	Vacuum Decay Aug. 2014	Moisture (ppm)
E-8 Samples	1209	57	1.4E-08	1.1E-08	2.0E-08	8.3E-09	8.7E-09	1.1E-08	Did Not Test	PLUGGED	--	16,871
	1207	133	2.1E-08	4.6E-08	3.6E-08	1.1E-08	8.5E-09	7.6E-08		PLUGGED	--	18,038
	1304	146	1.9E-08	4.4E-08	4.0E-08	6.3E-09	7.2E-09	4.6E-08		1.2E-09	4.0E-08	32,480
	1209	180	2.9E-08	4.8E-08	3.6E-08	7.6E-09	7.3E-08	7.3E-08		PLUGGED	--	15,850
	1207	334	1.2E-08	2.6E-08	2.4E-08	6.8E-09	2.7E-08	1.6E-08		PLUGGED	--	16,417

- **Plugging** *(Kr85 testing performed from 5/13 – 8/14)*
  - Kr85 qualification test data quantified all 5 parts as E-8 fine leakers
  - Kr85 verification test data identified 5 fully or partially plugged parts
  - Based on Lab A qualification versus verification data, data from all 5 parts is valid
- **CHLD vs Kr85 Correlation**
  - Both CHLD Labs D and E correlated 3 of the 5 known leakers within ½ order of magnitude to Kr85 qualification data.
  - Deviations between Lab D & E CHLD data needs further investigation to determine root cause. These differences may be a function of operator experience and equipment complexity.
- **MIL-STD Failure Criteria L Comparison**
  - MIL-STD-883J TM1014.14 L=1E-7: Test labs A-E would have passed all 5 parts
  - MIL-STD-750F TM1071.11 L=5E-9: Test labs A-E would have failed all 5 parts
    - *The latest revision of MIL-STD-883J TM1014.14 calls out L=5E-9 for Class K Hybrids*

CHLD Labs D and E correlated 3 of 5 parts within ½ order of magnitude

Data & Results: CHLD-Fine (E-9)

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Sample Set 1 Part Information (TO-257, Vol. = 0.23 cc)			Air Leak Rate Results (atm-cc/sec Air)									IGA Sep. 2014
			Kr85 Qualification			CHLD		Kr85 Verification				
Classification	LDC	SN	Lab A Aug. 2013	Lab B Jun. 2013	Lab C May 2013	Lab D Feb. 2014	Lab E Apr. 2014	Lab A Apr. 2014	Lab B	Lab C Jul. 2014	Vacuum Decay Aug. 2014	Moisture (ppm)
E-9 Samples	1304	145	3.4E-09	8.0E-09	7.0E-09	3.3E-09	2.4E-09	**PLUGGED**	Did Not Test	**>3E-6**	--	15,288
	1209	170	2.1E-09	5.5E-09	5.0E-09	2.4E-09	9.9E-09	**8.2E-10**		**PLUGGED**	--	12,865
	1207	289	4.6E-09	1.0E-08	1.0E-08	2.3E-09	1.8E-09	**PLUGGED**		**PLUGGED**	--	15,399
	1207	291	9.2E-09	9.0E-09	1.0E-08	2.6E-09	1.4E-08	**3.3E-09**		**PLUGGED**	--	17,229
	1207	299	1.7E-09	6.0E-09	5.0E-09	2.2E-09	1.7E-09	**PLUGGED**		6.6E-09	6.0E-09	16,185

- **Plugging** *(Kr85 testing performed from 5/13 – 8/14)*
  - Kr85 qualification test data quantified all 5 parts as fine leakers
  - Kr85 verification test data identified 5 fully or partially plugged parts
  - Based on Lab A qualification versus verification data, data from all 5 parts is questionable

Kr85 verification test data indicates all E-9 parts had plugging issues

Data & Results: OLT (Gross)

Sample Set 2 Part Information (TO-257, Vol. = 0.23 cc)			Air Leak Rate Results (atm-cc/sec Air)								IGA Sep. 2014
			Kr85 Qualification			OLT	Kr85 Verification				
Classification	LDC	SN	Lab A [1]	Lab B Aug. 2013	Lab C Aug 2013	Lab F Nov. 2013	Lab A Jan. 2014	Lab B	Lab C Nov. 2013	Vacuum Decay Aug. 2014	Moisture (ppm)
Gross Samples	1207	217	Did Not Test	Gross	Gross	7.4E-07	Gross	Did Not Test	Gross	--	15,421
	1206	219		Gross	Gross	4.0E-07	Gross		Gross	--	16,398
	1146	223		Gross	Gross	3.3E-07	Gross		Gross	--	18,854
	1209	227		Gross	Gross	1.5E-06	Gross		Gross	--	17,349
	1209	228		Gross	Gross	Gross	Gross		Gross	--	16,187

- **Plugging** (Kr85 testing performed from 8/13 – 1/14)
  - Kr85 qualification test data quantified all 5 parts as gross leakers
  - Kr85 verification test data did not identify any plugged parts
  - Based on qualification vs verification test data, all part data is valid
- **OLT vs Kr85 Correlation**
  - Lab F identified 4 of the 5 gross leakers as a fine leak value
  - Lab F phase maps did not characteristically identify the 4 parts as gross leakers (lids showed deflection)
- **MIL-STD Failure Criteria, L, Comparison**
  - MIL-STD-883J TM1014.14 L=1E-7: All test labs would have failed all 5 parts
  - MIL-STD-750F TM1071.11 L=5E-9: All test labs would have failed all 5 parts
    - *The latest revision of MIL-STD-883J TM1014.14 calls out L=5E-9 for Class K Hybrids*

OLT Lab F identified the leakers as gross or intermediate fine leakers

Data & Results: OLT-Fine (E-7)

Sample Set 2 Part Information (TO-257, Vol. = 0.23 cc)			Air Leak Rate Results (atm-cc/sec Air)								IGA Sep. 2014
			Kr85 Qualification			OLT[2]	Kr85 Verification				
Classification	LDC	SN	Lab A [1]	Lab B Aug. 2013	Lab C Aug 2013	Lab F Nov. 2013	Lab A Jan. 2014	Lab B	Lab C Nov. 2013	Vacuum Decay Aug. 2014	Moisture (ppm)
E-7 Samples	N/A	5	Did Not Test	7.6E-07	9.0E-07	4.4E-07	6.0E-07	Did Not Test	8.0E-07	6.0E-07	18,894
	N/A	83		7.0E-07	8.4E-07	6.3E-07	6.9E-07		6.4E-07	--	20,663
	N/A	86		2.0E-07	3.0E-07	N/D	1.0E-07		1.0E-07	1.0E-07	18,802
	N/A	88		4.0E-07	2.0E-07	7.8E-08	9.3E-08		1.3E-07	--	18,095
	1213	113		2.0E-07	3.0E-07	1.2E-07	2.1E-07		2.4E-07	--	15,428

Notes:
1. Samples were not sent to Lab A for initial testing. Samples were hand delivered to laboratory.
2. Data value marked N/D could not be reported because it was outside the 8.5E-9 atm-cc/Air (2.3E-8 atm-cc/He) OLT instrument test sensitivity.

- **Plugging** *(Kr85 testing performed from 8/13 – 8/14)*
  - Kr85 qualification test data quantified all 5 parts as fine leakers
  - Kr85 verification test data did not identify any plugged parts
  - Based on qualification vs verification test data, all part data is valid
- **OLT vs Kr85 Correlation**
  - OLT Lab F identified 4 of the 5 known leakers within a 1/2 order of magnitude
  - OLT Lab F was not able to detect 2 known fine leakers (SN's: 86, 88). SN 86 part fell within the sensitivity of their instrument even though they said it was not. *(See note 2 above)*
- **MIL-STD Failure Criteria L Comparison**
  - MIL-STD-883J TM1014.14 L=1E-7: Kr85 qualification test labs B and C would have failed all 5 parts. Kr85 verification test lab A passed 1 fine leaker (SN 88) which was within ½ order of magnitude of Kr85 Lab B and C test data. OLT Lab F would have passed 2 known leakers and failed 3 known leakers.
  - MIL-STD-750F TM1071.11 L=5E-9: Kr85 test labs would have failed all 5 parts; OLT Lab F would have failed 4 leakers. SN 86 part's status is unknown. *(See note 2 above)*

OLT correlated 4 of 5 parts within ½ order of magnitude

Data & Results: OLT-Fine (E-8)

Sample Set 2 Part Information (TO-257, Vol. = 0.23 cc)			Air Leak Rate Results (atm-cc/sec Air)								IGA Sep. 2014
			Kr85 Qualification			OLT[2]	Kr85 Verification				
Classification	LDC	SN	Lab A [1]	Lab B Aug. 2013	Lab C Aug 2013	Lab F Nov. 2013	Lab A Jan. 2014	Lab B	Lab C Nov. 2013	Vacuum Decay Aug. 2014	Moisture (ppm)
E-8 Samples	1213	100	Did Not Test	6.2E-08	5.6E-08	2.2E-08	6.9E-08	Did Not Test	6.0E-08	6.0E-08	20,438
	1213	105		3.0E-08	3.6E-08	N/D	3.4E-08		2.4E-08	--	17,091
	1213	107		3.4E-08	3.0E-08	N/D	1.1E-08		1.0E-08	1.4E-08	16,269
	1207	287		2.6E-08	2.0E-08	N/D	9.8E-09		2.0E-08	--	13,686
	1207	297		2.5E-08	1.6E-08	N/D	2.1E-08		2.0E-08	--	15,050

Notes:

1. Samples were not sent to Lab A for initial testing. Samples were hand delivered to laboratory.

2. Data value marked "N/D" could not be reported because it was outside the 8.5E-9 atm-cc/Air (2.3E-8 atm-cc/He) OLT instrument test sensitivity.

- **Plugging** *(Kr85 testing performed from 8/13 – 1/14)*
  - Kr85 qualification test data quantified all 5 parts as E-8 fine leakers
  - Kr85 verification test data did not identify any plugged parts
  - Based on qualification vs verification test data, all part data is valid
- **OLT vs Kr85 Correlation**
  - OLT Lab F was able to identify 1 of the 5 known leakers within a 1/2 order of magnitude
  - OLT Lab F was not able to detect 4 of the known fine leakers. These parts fell within the sensitivity of their instrument even though they said it was not. *(See note 2 above)*
- **MIL-STD Failure Criteria L Comparison**
  - MIL-STD-883J TM1014.14 L=1E-7: All test labs would have passed all 5 parts
  - MIL-STD-750F TM1071.11 L=5E-9: Kr85 test labs would have failed all 5 parts; OLT Lab F would have failed 1 part. The remaining 4 part's status is unknown. *(See Note 2 above)*
    - *The latest revision of MIL-STD-883J TM1014.14 calls out L=5E-9 for Class K Hybrids*

OLT did not test parts to a high enough sensitivity to detect entire E-8 range

Data & Results: OLT-Fine (E-9)

Sample Set 2 Part Information (TO-257, Vol. = 0.23 cc)			Air Leak Rate Results (atm-cc/sec Air)								IGA
			Kr85 Qualification			OLT	Kr85 Verification				
Classification	LDC	SN	Lab A	Lab B	Lab C	Lab F	Lab A	Lab B	Lab C	Vacuum Decay	Moisture (ppm)
E-9 Samples	Lab F test parameters were based on Failure Criteria of 1 E-7 atm-cc/sec Air (Table VII MIL-STD-883J TM1014.14, 0.23cc internal volume part) The equipment parameters to test to the Failure Criteria result in a 8.5E-9 atm-cc/sec He (2.3 E -8 atm-cc/sec He) equipment test sensitivity										

- **MIL-STD Failure Criteria L Issue**
  - MIL-STD-750F TM1071.11 L=5E-9
    - Kr85 and CHLD test labs demonstrated their ability to test to the higher sensitivities needed to comply with the tighter leak rates of MIL-STD-750F and MIL-STD-883J for Class K Hybrids
    - OLT Lab F did not test the E-9 test samples due to issues with extended bomb times and inexperience with testing to limits in this leak range.
    - No parts were tested.

OLT Lab F was not confident to test in the E-9 atm-cc/sec AIR Leak Rate Range

Correlation Study Observations

Correlation Kr85

- All Kr85 test labs demonstrate 100% correlation on qualification test data within ½ order of magnitude for both gross and fine leakers.
- All gross leaks and plugged parts were identified and fine leak rates were within ½ order of magnitude.
- During the verification phase Kr85 Lab A detected one detection limit cusp hanger in OLT Sample Set 2 E-7 known fine leakers (SN 88) that would be detected when using prudent manufacturers/test labs who employ a detection limit margin of one order of magnitude. SN 88 was within ½ order of magnitude of the qualification test data.

Correlation CHLD

- CHLD Labs D & E identified the gross leaking parts as gross or intermediate fine leakers.
- For E-7 known fine leakers, CHLD Lab D correlated 3 of 5 whereas CHLD Lab E correlated 5 of 5 parts within ½ order of magnitude.
- For E-8 known fine leakers, both CHLD Labs D & E correlated 3 of the 5 fine leakers within a ½ order of magnitude.
- For E-9 known fine leakers, data is inconclusive due to plugging.
- CHLD Labs D & E did not pass any known leakers for either test method (750/883).

Correlation Study Observations

Correlation OLT

- OLT Lab F was only able to identify 20% (1 of 5) of the gross leaking parts. The phase diagrams did not appear to indicate that the samples were gross leakers.
- For E-7 known fine leakers, OLT Lab F identified 4 of the 5 known fine leakers within a ½ order of magnitude. However, OLT Lab F would have passed 2 known leakers and failed 3 known leakers per the MIL-STD-883 test method. In comparison with MIL-STD-750 test method OLT would have failed 4 parts but SN 86 would have to be tested at a higher sensitivity than was used for this test.
- For E-8 known fine leakers, OLT Lab F would have passed all of 5 known fine leakers in accordance with MIL-STD-883 test method. Even though OLT test sensitivity was set at 8.5E-9 atm-cc/sec AIR they were unable to detect these leakers. For this same reason, OLT test conditions were not set up to test E-9 known leakers.

Lessons Learned

Plugging

- The **most reliable quantitative leak test** on parts manufactured with corrodible materials is the one performed during initial lot screening.
- Leaky parts can gradually or completely plug or unplug at anytime when manufactured with corrodible materials.

Test Method Modifications

- Both MIL-STD-750 and 883 test method conditions should be revised to employ a detection limit margin of at least one order of magnitude to the calculated reject limit for all leak test instruments. This will ensure that instrument and operator differences as well as detection limit cusp hangers are mitigated.
- Both MIL-STD-750 and 883 test method conditions for OLT should be modified based on the data obtained in this study which shows OLT Lab F was unable to consistently identify both gross leakers and fine leakers within the sensitivity of the equipment. A requirement should be added to the test method specifying OLT calibration sets shall include both gross leakers and a range of fine leakers to adequately cover the leak rate range.
- Deviations between CHLD test lab correlation data needs further investigation to determine root cause. These differences may be a function of operator experience, equipment complexities, and test method clarity.

Future Work

Correlation Study Phase II
Planning Stage

- **Parts:**
  - Currently trying to acquire an adequate amount of parts of the same package type with specified leak ranges to conduct a more complete statistically relevant correlation study.
- **Participants:**
  - Assembling a representative group of instrument equipment manufacturers as well as users.

Feedback

Backup Slides

Test Specifics: Kr85 Labs A, B, & C

Kr85 TO-257 Test Plan

Sample Set 1 Part Information (TO-257, Volume = 0.23 cc)			Test Conditions					
			Kr85 Qualification			Kr85 Verification		
Classification	LDC	SN	Lab A	Lab B	Lab C	Lab A	Lab B	Lab C
Gross Samples	1206	211	S.A. = 228 Gross Test 75 PSIA @ T = 0.01 hr	S.A. = 217 Gross Test 75 PSIA @ T = 0.01 hr followed by 75 PSIA @ T = 0.04 hr	S.A. = 200 Gross Test 75 PSIA @ T = 0.01 hr followed by 75 PSIA @ T = 0.1 hr	S.A. = 344 Gross Test 75 PSIA @ T = 0.01 hr	S.A. = 217 Gross Test 75 PSIA @ T = 0.01 hr followed by 75 PSIA @ T = 0.04 hr	S.A. = 200 Gross Test 75 PSIA @ T = 0.01 hr followed by 75 PSIA @ T = 0.1 hr
	1207	215						
	1146	221						
	1146	224						
	1209	229						
E-7 Samples	1213	103	S.A. = 228 Fine Test 75 PSIA @ T = 0.04 hr	S.A. = 217 Fine Test 75 PSIA @ T = 0.04 hr followed by 75 PSIA @ T = 0.1 hr	S.A. = 200 Fine Test 75 PSIA @ T = 0.1 hr followed by 75 PSIA @ T = 034 hr	S.A. = 344 Fine Test 75 PSIA @ T = 0.04 hr	S.A. = 217 Fine Test 75 PSIA @ T = 0.04 hr followed by 75 PSIA @ T = 0.1 hr	S.A. = 200 Fine Test 75 PSIA @ T = 0.1 hr followed by 75 PSIA @ T = 034 hr
	1213	109						
	1213	119						
	1207	316						
	1207	351						
E-8 Samples	1209	57	S.A. = 228 Fine Test 75 PSIA @ T = 0.34 hr	S.A. = 217 Fine Test 75 PSIA @ T = 0.1 hr followed by 75 PSIA @ T = 1.83 hr	S.A. = 200 Fine Test 75 PSIA @ T = 0.1 hr followed by 75 PSIA @ T = 0.63 hr	S.A. = 344 Fine Test 75 PSIA @ T = 0.34 hr	S.A. = 217 Fine Test 75 PSIA @ T = 0.1 hr followed by 75 PSIA @ T = 1.83 hr	S.A. = 200 Fine Test 75 PSIA @ T = 0.1 hr followed by 75 PSIA @ T = 0.63 hr
	1207	133						
	1304	146						
	1209	180						
	1207	334						
E-9 Samples	1304	145	S.A. = 228 Fine Test 75 PSIA @ T = 0.68 hr	S.A. = 217 Fine Test 75 PSIA @ T = 1.83 hr	S.A. = 200 Fine Test 75 PSIA @ T = 0.63 hr	S.A. = 344 Fine Test 75 PSIA @ T = 0.68 hr	S.A. = 217 Fine Test 75 PSIA @ T = 1.83 hr	S.A. = 200 Fine Test 75 PSIA @ T = 0.63 hr
	1209	170						
	1207	289						
	1207	291						
	1207	299						

It is customary for Labs B and C to include intermediate tests for E-7 and E-8 ranges to avoid introducing excess quantities of Kr85 when other labs will also be testing these devices.

Test Specifics: CHLD Labs D & E

CHLD TO-257 Test Plan

Part	Leak Rate Range (atm-cc/sec Air)	Test Conditions								Method			
		Bomb Conditions			Howl-Mann Calculatons			Wait Time	Total Dwell Time	T Times	Chamber Size	Insert?	Batch
		Total (hours)	Pressure		Volume (cc)	L (atm-cc/sec Air)	R1 (atm-cc/sec He)						
			(PSIA)	(PSIG)									
TO-257	Gross	0.5	74.7	60	0.23	1.00E-07	2.8E-09	10 min	1 hr max	10/10/30/30/5	Medium	Yes	No
	E-7	0.5	"	"	"	"	2.8E-09	1.5 hrs	2.0 hrs	"	"	"	"
	E-8	2.0	"	"	"	"	1.1E-10	"	"	"	"	"	"
	E-9	24.0	"	"	"	"	3.4E-10	"	"	"	"	"	"

Test Specifics: OLT Lab F

- OLT was performed by Lab F using NorCom 2020
  - NorCom 2020 resolution: 15nm
  - Pressurization gas: Helium

Parameters	TO-257
Package Cavity [cc]	0.23
Test Time	45 min
Helium pressure +/- modulation [psi]	57.3psi +/- 0.2
OLT Test Sensitivity for this part† [atm cc/sec air]	2.3E-8
Fine Leak Limit (L) [atm cc/sec air] per MIL-STD-883J	1E-7
Number of parts tested	15

(†) Based on the test parameters chosen by Lab F they were unable to obtain the sensitivity necessary to test the bulk of the E-8 and all of the E-9 parts.

Test Specifics: OLT Lab F

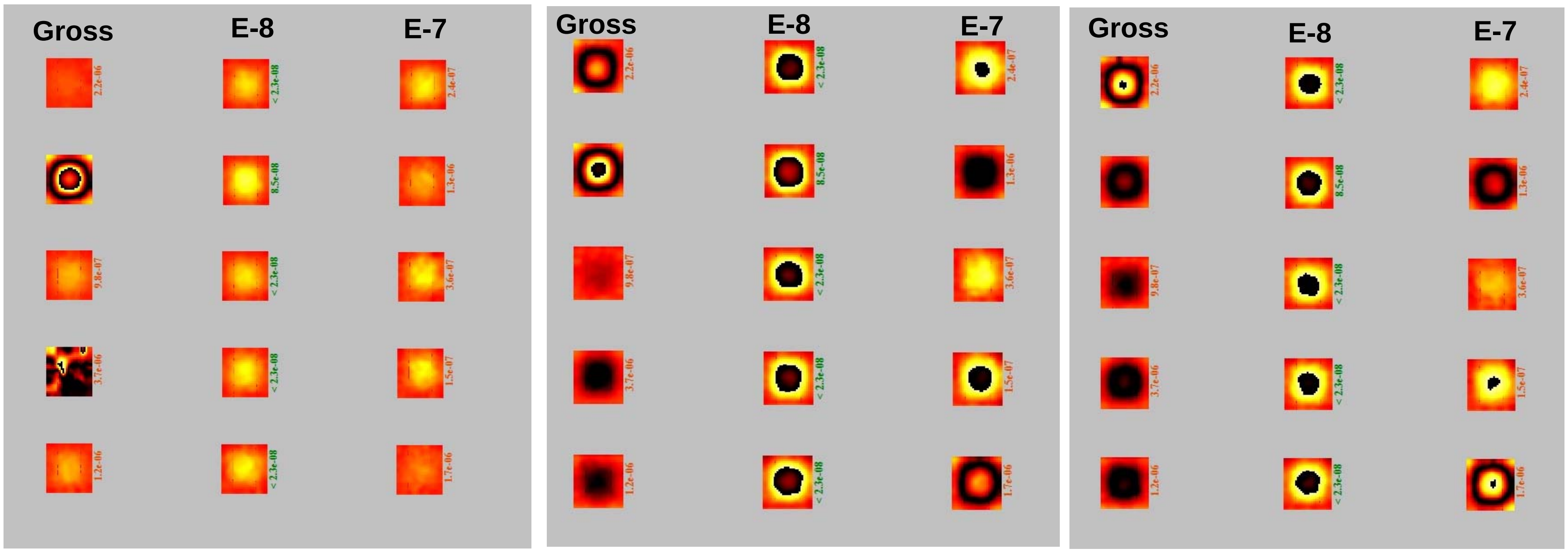
- **Lab F's Objective:**
  - Develop an Optical Leak Program for this module that can be used for testing and distinguishing passing parts from failing parts per MIL-STD-883 Method 1014 C_4 and C_5.
- **Parts were tested to check if they meet the critical rate or not:**
  - To verify accuracy of leak rate data provided by OLT parts should be tested with other leak test methods (pressurized He or Kr/85 for fine leakers) for confirmation
- **Lab F's Programming Process:**
  - Prior to testing a fixture was designed and fabricated for mounting the modules in the machine.
  - Basic parameters were selected from a list of programs for modules with similar internal volume and cover thickness/material.
  - Modules were run through 12 iterations to refine the program and parameters to correctly distinguish passing modules from failing modules based on the Phase Maps.
  - Modules were tested in various configurations to ensure the program worked regardless of socket position on the handling fixture.

Test Specifics: OLT Lab F

- **Programming Challenges**
  - To develop a program with some confidence in the program you must have samples that are both known hermetic parts and known leaking parts to ensure your program can effectively detect both types of parts.
  - Initial data from the 33750-D modules identified as the E-8 samples did not appear to be in line with hermetic modules based on the phase map data.
  - After 7 iterations it became apparent that the “Gross Reject” samples had been swapped with the E-8 samples.
  - Iterations 8-12 were performed using the “Gross Reject” modules as the baseline for passing parts and the program was developed.

Test Specifics: OLT Lab F

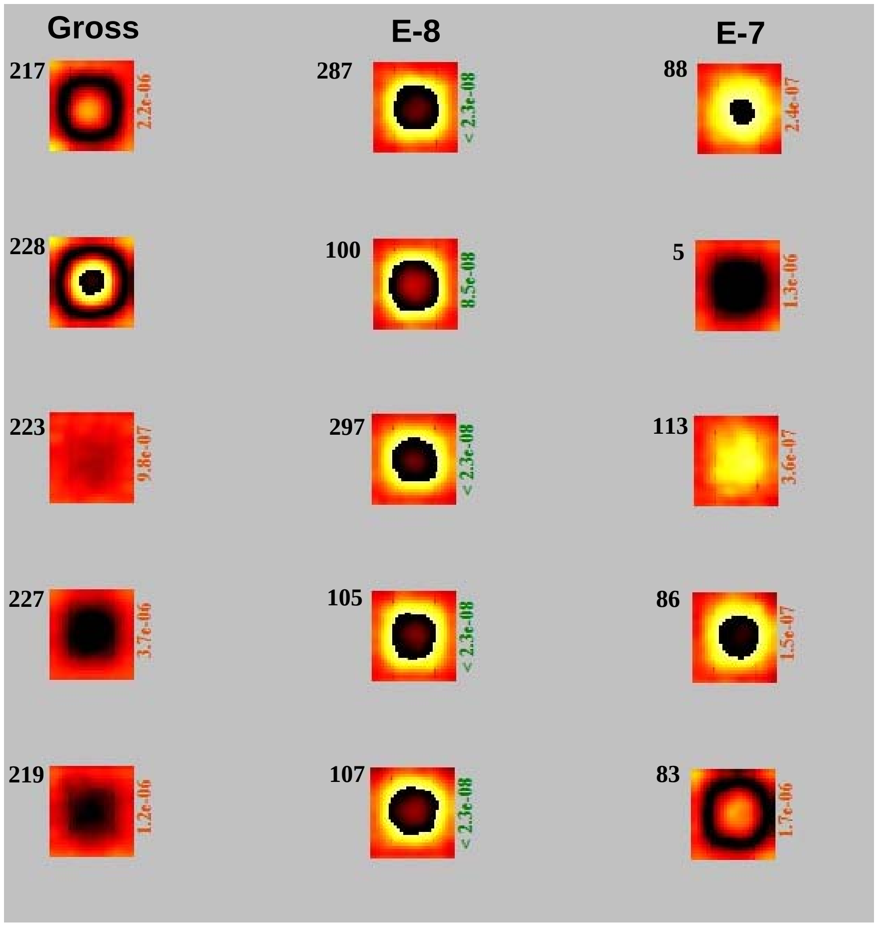
- **Lab F's Phase Maps:**
  - Program takes 100 frames.
    - Phase maps for frames 4, 25 & 43 (randomly selected) are provided below
    - Phase maps for frame 4 is not used but shows that the part is stabilizing to the test conditions
  - Frames should show deflection centered on the part with concentric rings for fine leaks
  - Frames should show no deflection for gross leaks
  - See slide 31 for a close up of frames 25 and 43 which identify serial numbers and show a larger image for phase map comparison of pressure differences during testing.



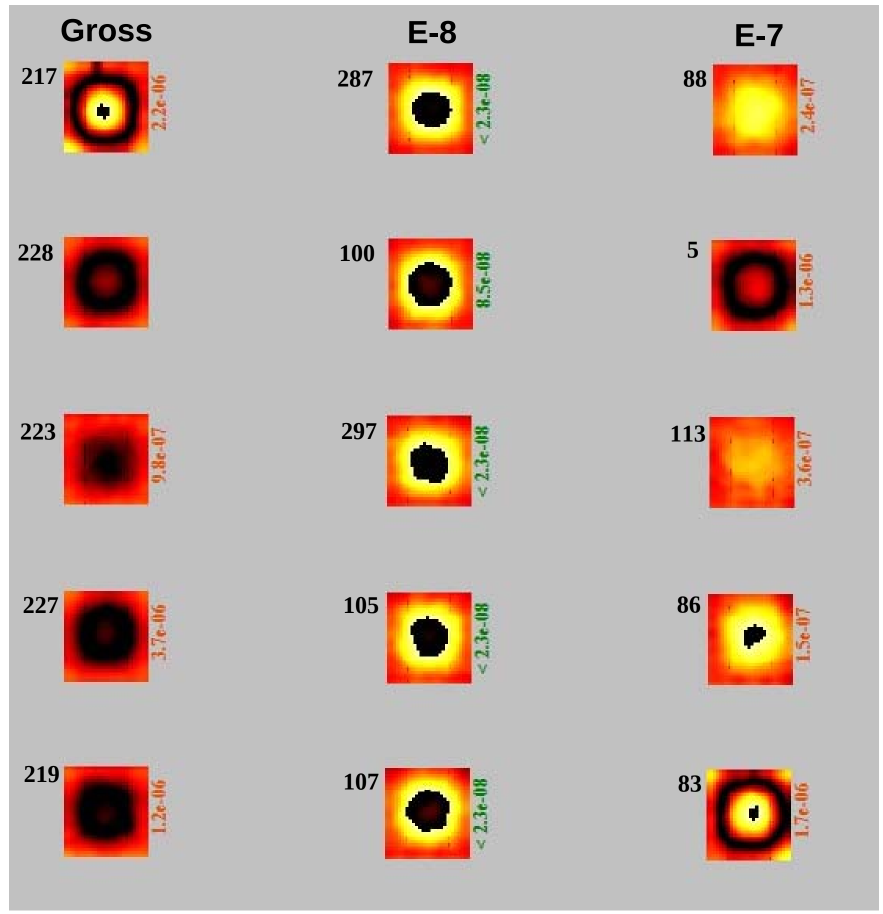
Frame 4 **Frame 25** **Frame 43**

Data & Results: OLT Lab F

- Program takes 100 frames.
  - Phase maps for frames 25 & 43 (randomly selected) are shown below. Frame 25 represents covers deflecting under pressure while Frame 43 shows pressure being relieved off of the part.
- Fine Leaks: Frames should show lid deflection centered on the part (concentric rings)
- Gross Leaks: Frames should show no lid deflection (SN 228 was identified as a Gross Leaker)



Frame 25



Frame 43

Test Specifics: OLT Lab F

- **Lab F's Interpretation of the Results:**
  - Leak rate parts were tested to: 2.3 x 10^{-8} atm-cc/sec He (from MIL-Std-883 method 1014)
  - Based on the results the "Gross Rejects" should be the E-8 parts, the E-8 parts should be the Gross Reject parts.
  - SN 86 is very close to passing.
  - Run 12 was performed after swapping the Gross Reject and the E-8 parts in the tray to verify results don't change based on tray position.

We have shown in this study that this is not the case….. The gross parts are gross leakers.

Test Specifics: OLT Lab F

Lab F's Notes & Observations on Optical Leak Testing:

- Unlike pressurized He or Kr/85 test which provide a leak rate for each part, optical leak test provides a pass or fail against a required leak rate (based on package size and volume) for known good parts
- To develop a program with confidence in the program you must have samples that are both known hermetic parts and known leaking parts to ensure your program can effectively detect both types of parts.
  - Must have confirmed hermetic parts are hermetic. Confirmation in having a hermetic part for programming OLT is critical
  - Lab F performs pressurized He leak test on hermetic parts to confirm hermeticity prior to programming OLT
- To verify accuracy of leak rate data provided by OLT, parts should be tested with other leak test methods (pressurized He or Kr/85 for fine leakers) for confirmation
- Higher leak rate sensitivity can be obtained by increasing pressure and test duration (Recommended)
- Lab F verifies OLT on a daily basis using known good (hermetic) parts

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Data & Results: CHLD (Gross & Fine)

Sample Set 1 Part Information (TO-257, Vol. = 0.23 cc)			Air Leak Rate Results (atm-cc/sec Air)									IGA Sep. 2014
			Kr85 Qualification			CHLD		Kr85 Verification				
Classification	**LDC**	**SN**	**Lab A Aug. 2013**	**Lab B Jun. 2013**	**Lab C May 2013**	**Lab D Feb. 2014**	**Lab E Apr. 2014**	**Lab A Apr. 2014**	**Lab B**	**Lab C Jul. 2014**	**Vacuum Decay Aug. 2014**	**Moisture (ppm)**
Gross Samples	1206	211	Gross	Gross	Gross	8.9E-07	1.3E-06	Gross	**Did Not Test**	Gross	--	23,777
	1207	215	Gross	Gross	Gross	1.1E-06	Gross	Gross		Gross	--	17,161
	1146	221	Gross	Gross	Gross	1.5E-06	5.2E-08	**PLUGGED**		**PLUGGED**	--	11,717
	1146	224	Gross	Gross	Gross	1.9E-06	Gross	Gross		Gross	--	18,590
	1209	229	Gross	Gross	Gross	Gross	Gross	Gross		Gross	1.7E-06	15,533
10^{-7} Samples	1213	103	1.0E-07	2.4E-07	1.4E-07	8.7E-08	3.0E-07	1.0E-07		**PLUGGED**	--	10,200
	1213	109	1.4E-07	2.8E-07	2.0E-07	1.7E-08	3.9E-07	1.6E-07		7.0E-07	--	10,400
	1213	119	1.1E-07	1.4E-07	1.0E-07	1.4E-08	2.7E-07	1.4E-07		**PLUGGED**	--	15,700
	1207	316	4.4E-07	8.0E-07	6.4E-07	1.0E-06	8.6E-07	5.1E-07		1.4E-07	--	38,440
	1207	351	1.7E-07	3.0E-07	2.0E-07	1.7E-07	2.8E-07	1.6E-07		**4.3E-09**	--	14,964
10^{-8} Samples	1209	57	1.4E-08	1.1E-08	2.0E-08	8.3E-09	8.7E-09	1.1E-08		**PLUGGED**	--	16,871
	1207	133	2.1E-08	4.6E-08	3.6E-08	1.1E-08	8.5E-09	7.6E-08		**PLUGGED**	--	18,038
	1304	146	1.9E-08	4.4E-08	4.0E-08	6.3E-09	7.2E-09	4.6E-08		**1.2E-09**	4.0E-08	32,480
	1209	180	2.9E-08	4.8E-08	3.6E-08	7.6E-09	7.3E-08	7.3E-08		**PLUGGED**	--	15,850
	1207	334	1.2E-08	2.6E-08	2.4E-08	6.8E-09	2.7E-08	1.6E-08		**PLUGGED**	--	16,417
10^{-9} Samples	1304	145	3.4E-09	8.0E-09	7.0E-09	3.3E-09	2.4E-09	**PLUGGED**		**>3E-6**	--	15,288
	1209	170	2.1E-09	5.5E-09	5.0E-09	2.4E-09	9.9E-09	**8.2E-10**		**PLUGGED**	--	12,865
	1207	289	4.6E-09	1.0E-08	1.0E-08	2.3E-09	1.8E-09	**PLUGGED**		**PLUGGED**	--	15,399
	1207	291	9.2E-09	9.0E-09	1.0E-08	2.6E-09	1.4E-08	**3.3E-09**		**PLUGGED**	--	17,229
	1207	299	1.7E-09	6.0E-09	5.0E-09	2.2E-09	1.7E-09	**PLUGGED**		6.6E-09	6.0E-09	16,185

Data & Results: OLT (Gross & Fine)

Sample Set 2 Part Information (TO-257, Vol. = 0.23 cc)			Air Leak Rate Results (atm-cc/sec Air)								IGA Sep. 2014
			Kr85 Qualification			OLT[2]	Kr85 Verification				
Classification	LDC	SN	Lab A [1]	Lab B Aug. 2013	Lab C Aug 2013	Lab F Nov. 2013	Lab A Jan. 2014	Lab B	Lab C Nov. 2013	Vacuum Decay Aug. 2014	Moisture (ppm)
Gross Samples	1207	217	Did Not Test	Gross	Gross	7.4E-07	Gross	Did Not Test	Gross	--	15,421
	1206	219		Gross	Gross	4.0E-07	Gross		Gross	--	16,398
	1146	223		Gross	Gross	3.3E-07	Gross		Gross	--	18,854
	1209	227		Gross	Gross	1.5E-06	Gross		Gross	--	17,349
	1209	228		Gross	Gross	Gross	Gross		Gross	--	16,187
10^{-7} Samples	N/A	5		7.6E-07	9.0E-07	4.4E-07	6.0E-07		8.0E-07	6.0E-07	18,894
	N/A	83		7.0E-07	8.4E-07	6.3E-07	6.9E-07		6.4E-07	--	20,663
	N/A	86		2.0E-07	3.0E-07	N/D	1.0E-07		1.0E-07	1.0E-07	18,802
	N/A	88		4.0E-07	2.0E-07	7.8E-08	9.3E-08		1.3E-07	--	18,095
	1213	113		2.0E-07	3.0E-07	1.2E-07	2.1E-07		2.4E-07	--	15,428
10^{-8} Samples	1213	100		6.2E-08	5.6E-08	2.2E-08	6.9E-08		6.0E-08	6.0E-08	20,438
	1213	105		3.0E-08	3.6E-08	N/D	3.4E-08		2.4E-08	--	17,091
	1213	107		3.4E-08	3.0E-08	N/D	1.1E-08		1.0E-08	1.4E-08	16,269
	1207	287		2.6E-08	2.0E-08	N/D	9.8E-09		2.0E-08	--	13,686
	1207	297		2.5E-08	1.6E-08	N/D	2.1E-08		2.0E-08	--	15,050
10^{-9} Samples	Lab F test parameters were based on Failure Criteria of 1 E-7 atm-cc/sec Air (Table VII MIL-STD-883J TM1014.14, 0.23cc internal volume part) The equipment parameters to test to the Failure Criteria result in a 8.5E-9 atm-cc/Air (2.3 E -8 atm-cc/sec He) OLT equipment test sensitivity										

Notes:

1. Samples were not sent to Lab A for initial testing. Samples were hand delivered to laboratory.
2. Data value marked "N/D" could not be reported because it was outside the 8.5E-9 atm-cc/Air (2.3E-8 atm-cc/He) OLT instrument test sensitivity.

IGA Data: CHLD Sample Set

Sample ID		Gross Samples					E-7 Samples					E-8 Samples					E-9 Samples				
		211	215	221	224	229	103	109	119	316	351	57	133	146	180	334	145	170	289	291	299
Ion Source Pressure	torr	1.1E-05	1.3E-05	1.1E-05	1.1E-05	1.0E-05	6.8E-06	5.6E-06	5.2E-06	3.0E-06	1.0E-05	1.5E-05	9.4E-06	2.6E-06	1.1E-05	1.0E-05	1.1E-05	1.6E-05	2.0E-05	1.6E-05	1.6E-05
Nitrogen	%v	76.7	76.7	78.5	77.2	76.6	79.4	78.7	78.8	75.2	77.7	75.6	78.3	76.8	79.1	78.6	77.1	76.4	77.4	75.4	77.9
Oxygen	%v	19.9	20.5	19.4	19.9	20.9	16.4	16.2	15.9	19.4	17.9	21.3	17.7	18.1	17.3	17.9	20.3	17.7	20	19.9	19.1
Argon	ppmv	8,985	9,723	8,408	9,487	9,106	10,000	10,600	10,200	9,524	10,056	10,100	9,424	10,900	9,411	9,675	10,200	8,841	10,008	9,031	9,979
CO_2	ppmv	1,464	1,611	704	1,585	709	21,300	28,700	25,700	5,344	17,605	3,365	11,600	7,613	10,110	4,988	652	1,159	829	1,664	3,327
Moisture	ppmv	23,777	17,161	11,717	18,590	15,533	10,200	10,400	15,700	38,440	14,964	16,871	18,038	32,480	15,850	16,417	15,288	12,865	15,399	17,229	16,185
Hydrogen	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methane	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Helium	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4128	ND	35900	ND	18700	ND
Fluorocarbons	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Krypton	ppmv	ND	ND	ND	ND	ND	530	784	640	221	827	60	304	296	260	98	ND	ND	ND	ND	284
Unknown	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Comments:

1. All samples were tested on ORS HR-IVA system
2. All samples were prebaked at 100°C for 16-24 hours
3. All samples were tested at 100°C
4. If listed, "Unknown" ppmv values are classified as unidentified organic compound(s) in the original test report

IGA Data: OLT Sample Set

Sample ID		Gross Samples					E-7 Samples					E-8 Samples				
		217	219	223	227	228	5	83	86	88	113	100	105	107	287	297
Ion Source Pressure	torr	1.3E-05	1.4E-05	1.2E0-5	1.1E-05	9.9E-06	1.4E-05	1.5E-05	1.7E-05	2.0E-05	2.0E-05	1.2E-05	2.1E-05	1.8E-05	2.1E-05	2.1E-05
Nitrogen	%v	75.6	75.5	75.2	75.6	75.6	75.5	75.3	75.5	75.7	77.5	75.2	75.7	75.8	74.2	76
Oxygen	%v	21.7	21.8	21.8	21.6	21.8	21.5	21.5	21.5	21.5	20	21.7	21.5	21.5	20.9	21.5
Argon	ppmv	9,725	9,491	9,536	9,464	9,446	9,404	9,099	9,525	9,188	8,830	9,539	9,443	9,520	9,520	9,534
CO_2	ppmv	1,345	1,429	1,413	890	695	1,038	1,829	1,133	790	786	869	965	991	924	983
Moisture	ppmv	15,421	16,398	11,717	17,349	16,187	18,894	20,663	18,802	18,095	15,428	20,438	17,091	16,269	13,686	15,050
Hydrogen	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methane	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Helium	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.45	ND
Fluorocarbons	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Krypton	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Unknown	ppmv	ND	ND	ND	ND	ND	ND	ND	ND	ND	50	140	78	ND	50	119

Comments:

1. All samples were tested on ORS HR-IVA system
2. All samples were prebaked at 100°C for 16-24 hours
3. All samples were tested at 100°C
4. If listed, "Unknown" ppmv values are classified as unidentified organic compound(s) in the original test report

Kr85 Vacuum Decay Method

1. Measure Kr^{85} leak rate (atm-cc/sec)
2. Establish C/M, or Kr^{85} molecules in part.
3. Place device in vacuum, < 10 mm Hg, for 1 or more weeks
4. Remove and read Kr^{85} C/M at fixed intervals to measure the number of Kr^{85} molecules leaving the part
5. Molecular flow leaks ($<10^{-6}$) produce a "linear decay"
6. $P_t = P_o e^{-kt}$

   Where:

   P_t = partial pressure Kr^{85} (C/M) at time 't'

   P_o = original partial pressure Kr^{85} (C/M)

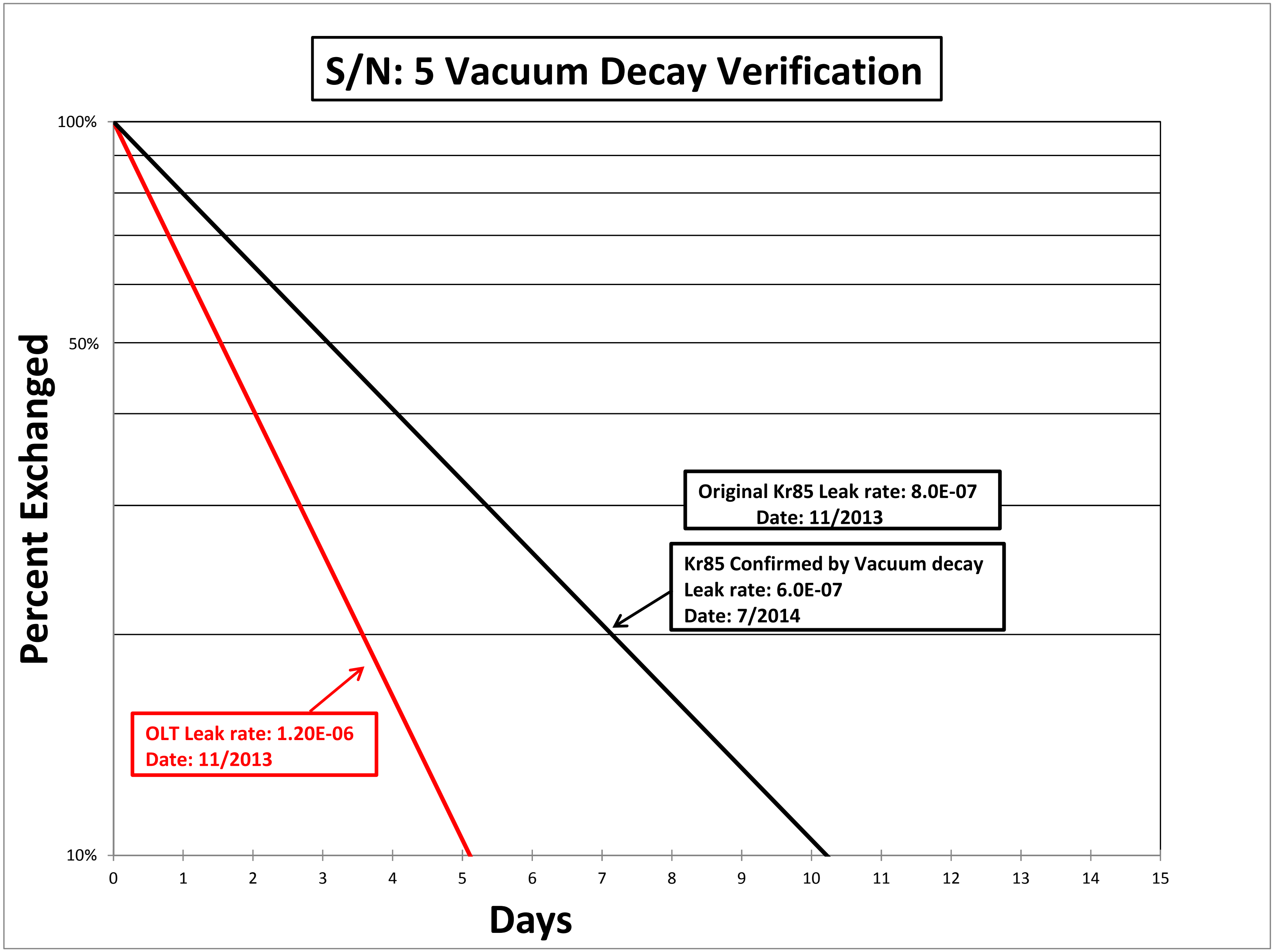
   k = leak rate of the device ÷ cavity volume (cc)

   t = time in seconds
7. The % loss of Kr^{85} is compared with the theoretical gas exchange for L/R vs Volume vs Time. This comparison produces a "Vacuum Decay Curve".

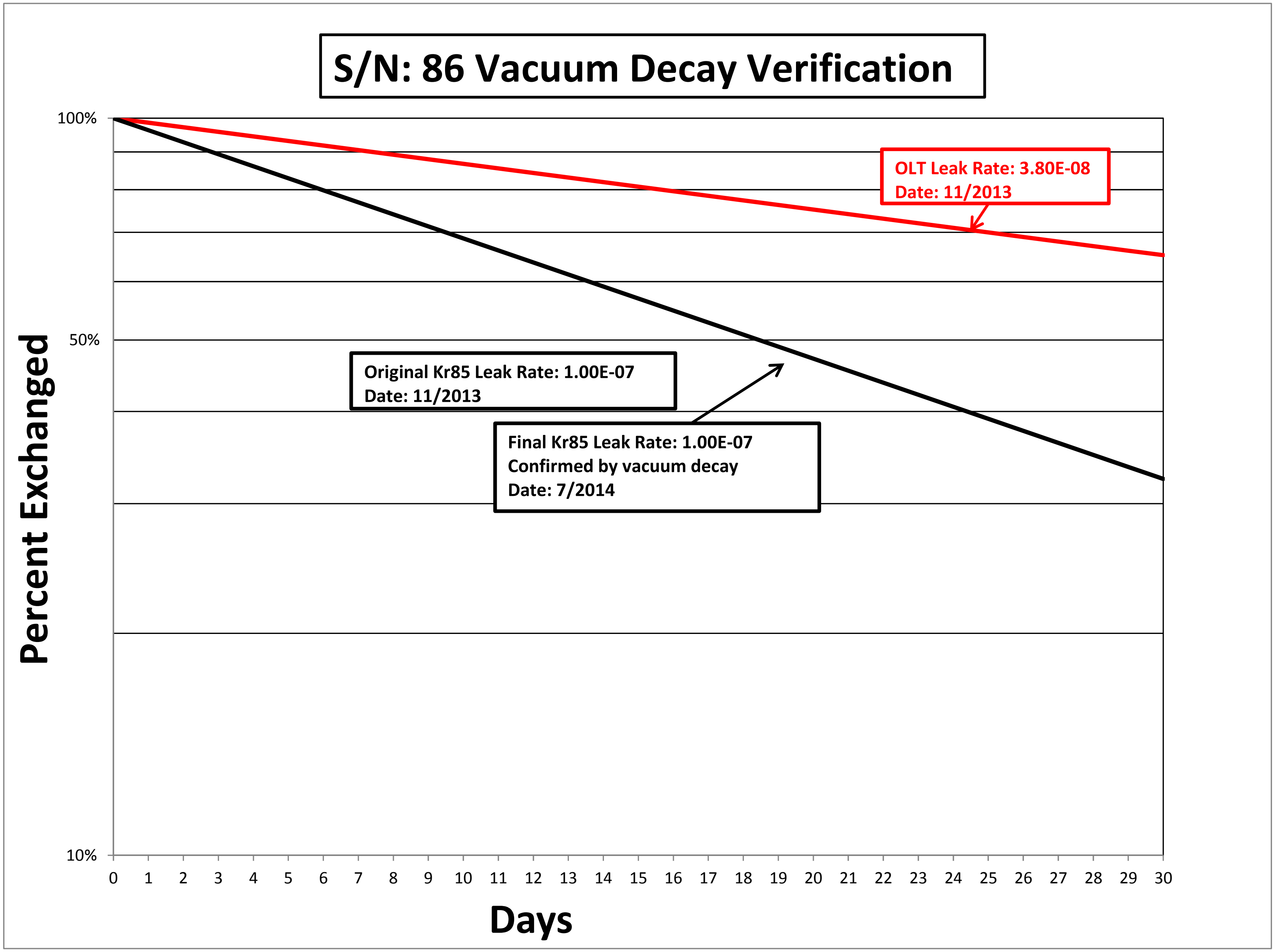
Kr85 Vacuum Decay Data Example

Days	C/M	C/M* % loss	Theoretical gas Exchange % loss	Theoretical gas Exchange % Remains
0	17,241	-	-	-
1	~16,300	~5	5.60	94.40
2	~15,000	~13	10.9	89.1
3	~14,500	~16	15.9	84.1
4	~13,500	~18	20.6	79.4
5	~12,500	~27	25	75
6	~12,000	~30	29	71
7	~11,400	~34	33	67
8	~10,800	~38	37	63
9	~10,100	~41	40.5	59.6
10	~ 9,600	~44	44	56
11	~ 9,050	~48	47	53
12	~ 8,600	~50	50	50

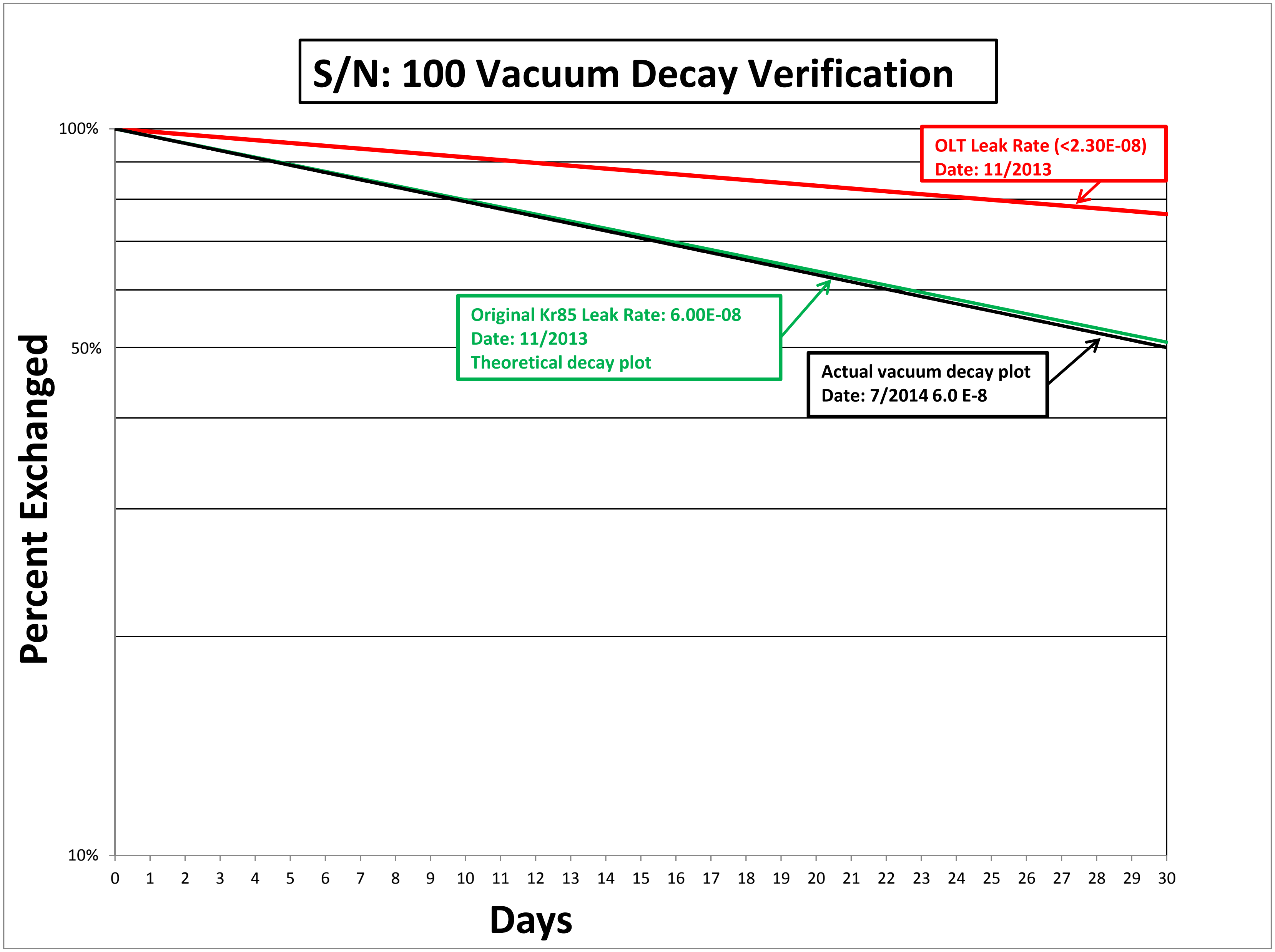
Kr85 Vacuum Decay: OLT SN 5



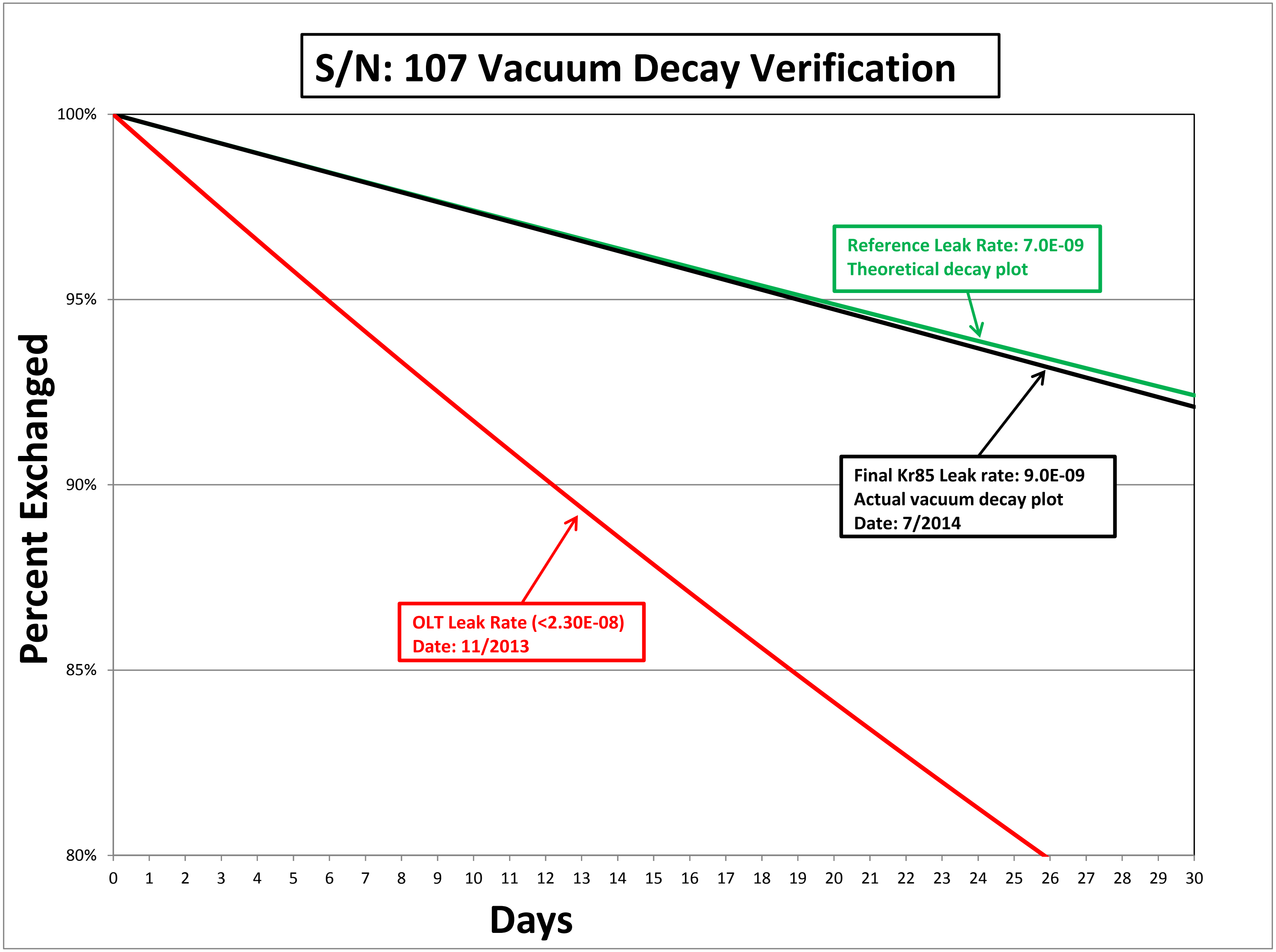
Kr85 Vacuum Decay: OLT SN 86



Kr85 Vacuum Decay: OLT SN 100



Kr85 Vacuum Decay: OLT SN 107



Leak Rate Limits

What are the leak rate limits?

- **MIL-STD-750F, Test Method 1071.11 “Hermetic Seal”**
  - *Equivalent standard leak rates (atm cc/s air) for volumes:*
    - ❑ ≤ 0.002 cc: 5E-10
    - ❑ > 0.002 and ≤ 0.02 cc: 1E-9
    - ❑ > 0.02 and ≤ 0.5 cc: 5E-9
    - ❑ > 0.5 cc: 1E-8
- **MIL-STD-883J, Test Method 1014.14 “Seal”**
  - *Equivalent standard leak rates (atm cc/s air) for volumes:*
    - ❑ ≤ 0.05 cc: 5E-8 except 1E-9 for Hybrid Class K
    - ❑ > 0.05 and ≤ 0.4 cc: 1E-7 except 5E-9 for Hybrid Class K
    - ❑ > 0.4 cc: 1E-6 except 1E-8 for Hybrid Class K

Atmospheric Exchange

How do we determine optimum leak rate requirements?

Leak Rates : Vol cc : Time to Exchange 50% atmoshphere

Volume	1.00E-06	5.00E-07	1.00E-07	5.00E-08	1.00E-08	5.00E-09	1.00E-09	5.00E-10
0.002 cc	0.4 *Hrs*	0.8 *Hrs*	3.9 *Hrs*	7.7 *Hrs*	1.6 *Days*	3.2 *Days*	16.0 *Days*	32 *Days*
0.01 cc	1.9 *Hrs*	3.9 *Hrs*	1 *Days*	2 *Days*	8.0 *Days*	16 *Days*	80 *Days*	160.5 *Days*
0.1 cc	19 *Hrs*	2 *Days*	8 *Days*	16 *Days*	80.2 *Days*	160 *Days*	2.2 *Years*	4.4 *Years*
0.4 cc	3 *Days*	6 *Days*	32 *Days*	64 *Days*	321 *Years*	2 *Years*	8.8 *Years*	17.6 *Years*
0.75 cc	6 *Days*	12 *Days*	60 *Days*	120.3 *Days*	2 *Years*	3 *Years*	16 *Years*	33.0 *Years*
1 cc	8 *Days*	16 *Days*	80 *Days*	160.5 *Days*	2 *Years*	4 *Years*	22 *Years*	44 *Years*
3 cc	24 *Days*	48 *Days*	240.7 *Years*	1.3 *Years*	7 *Years*	13 *Years*	66 *Years*	132 *Years*
5 cc	40 *Days*	80 *Days*	1.1 *Years*	2.2 *Years*	11 *Years*	22 *Years*	110 *Years*	220 *Years*
8 cc	64 *Days*	128.4 *Days*	1.8 *Years*	3.5 *Years*	18 *Years*	35 *Years*	176 *Years*	352 *Years*
10 cc	80 *Days*	160.5 *Days*	2.2 *Years*	4.4 *Years*	22 *Years*	44 *Years*	220 *Years*	440 *Years*
12 cc	96 *Days*	192.5 *Days*	2.6 *Years*	5.3 *Years*	26 *Years*	53 *Years*	264 *Years*	528 *Years*
15 cc	120.3 *Days*	240.7 *Days*	3.3 *Years*	6.6 *Years*	33 *Years*	66 *Years*	330 *Years*	659 *Years*

Volume	1.00E-10
0.002 cc	4.4 *Years*

Volume	5.00E-11
0.002 cc	320.9 *Days*

Volume	1.00E-11
0.01 cc	2.2 *Years*

$$P_t = P_0 e^{-(kt)}$$

$$k = \frac{\text{leak rate}}{\text{vol cc}}$$

t = *time (sec)*

This "Exchange Table" shows the number of 'hours,' 'days,' or 'years' required for a device to ingest 50% of the atmoshphere to which it is exposed, based on the volume of the part, (cc), and the leak rate of the part.

These exchange values have been studied and confirmed using Kr85 measured leak rates and IGA evaluation.

MIL-STD-883 TM 1014 Leak Rate Limits (yellow)

MIL-STD-750 TM 1071 Leak Rate Limits (green)

Atmospheric Exchange

How do we determine optimum leak rate requirements?

Leak Rates : Vol cc : Time to Exchange 90% atmoshphere

Volume	1.00E-06	5.00E-07	1.00E-07	5.00E-08	1.00E-08	5.00E-09	1.00E-09	5.00E-10
0.002 cc	1.3 Hrs	2.6 Hrs	12.8 Hrs	1.1 Days	5.3 Days	10.7 Days	53.3 Days	107 Days
0.01 cc	6.4 Hrs	12.8 Hrs	3 Days	5 Days	26.7 Days	53 Days	267 Days	1.5 Years
0.1 cc	3 Days	5 Days	27 Days	53 Days	266.5 Days	1 Years	7.3 Years	14.6 Years
0.4 cc	11 Days	21 Days	107 Days	213 Days	3 Years	6 Years	29.2 Years	58.4 Years
0.75 cc	20 Days	40 Days	200 Days	1.1 Years	5 Years	11 Years	55 Years	109.5 Years
1 cc	27 Days	53 Days	267 Days	1.5 Years	7 Years	15 Years	73 Years	146 Years
3 cc	80 Days	160 Days	2.2 Years	4.4 Years	22 Years	44 Years	219 Years	438 Years
5 cc	133 Days	267 Days	3.7 Years	7.3 Years	37 Years	73 Years	365 Years	730 Years
8 cc	213 Days	1.2 Years	5.8 Years	11.7 Years	58 Years	117 Years	584 Years	1,168 Years
10 cc	267 Days	1.5 Years	7.3 Years	14.6 Years	73 Years	146 Years	730 Years	1,460 Years
12 cc	320 Days	1.8 Years	8.8 Years	17.5 Years	88 Years	175 Years	876 Years	1,752 Years
15 cc	1.1 Years	2.2 Years	10.95 Years	21.9 Years	109.5 Years	219 Years	1,095 Years	2,190 Years

Volume	1.00E-10
0.01 cc	7.3 Years

Volume	5.00E-11
0.002 cc	2.9 Years

Volume	1.00E-11
0.002 cc	14.6 Years

MIL-STD-883 TM 1014 Leak Rate Limits

MIL-STD-750 TM 1071 Leak Rate Limits

$$P_t = P_0 e^{-(kt)}$$

$$k = \frac{\text{leak rate}}{\text{vol cc}}$$

t = time (sec)

This "Exchange Table" shows the number of 'hours,' 'days,' or 'years' required for a device to ingest 90% of the atmoshphere to which it is exposed, based on the volume of the part, (cc), and the leak rate of the part.

These exchange values have been studied and confirmed using Kr85 measured leak rates and IGA evaluation.